Knowledge management without management - shadow IT in knowledge Intensive manufacturing practices

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KNOWLEDGE MANAGEMENT WITHOUT MANAGEMENT - SHADOW IT IN KNOWLEDGE-INTENSIVE MANUFACTURING PRACTICES

Research paper

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Abstract

The voluntary use of private device by employees without formal approval of the IT department, commonly termed Shadow IT, is an increasingly widespread phenomenon. In this paper, we study the role of private smartphones (and related applications like WhatsApp) in knowledge-intensive practices in the manufacturing domain. With an in-depth case study based on data gained from observations and interviews, we are able to empirically illustrate why workers use their private smartphones (contrary to company guidelines) and how they find significant gains of productivity by using the 'forbidden' applications. Our study contributes to knowledge management research by showing how private IT use can change existing knowledge management practices. At the same time, we are able to give rich insights into the rise of Shadow IT in a manufacturing context which takes place in a self-organised way without knowledge of the management. This enables us to take a step towards a knowledge management strategy perspective on Shadow IT.

Keywords: Shadow IT, Manufacturing, Knowledge Management, Knowledge Management Strategy

1 Introduction

A number of reports from industry and academic studies alike point to the increased usage of IT resources without the knowledge of the senior management. For instance, although smart devices are often forbidden at the work place due to security and health reasons, employees bend the rules and use their private devices anyway (Silic & Back, 2014). In a survey with around 4.000 employees, 52% of the participants indicated that they used their private devices for work related activities (Harris et al., 2012). This occurs mostly in situations where existing organisational IT are malfunctioning or prevailing injunctive IT norms are perceived as inefficient by employees (Haag & Eckhardt, 2014). When employees rationalize their use of personal IT devices to facilitate work practices due to the inefficiencies of existing IT infrastructure, but their actions still represent an injunction of existing IT norms this is commonly termed Shadow IT (György et al., 2012; Stadtmueller, 2013).

The phenomenon of Shadow IT is increasingly observed in many companies. Existing research considers e.g. on how to effectively govern Shadow IT (György et al., 2012), the emergence of shadow systems after the implementation of ERP systems (Behrens & Sedera, 2004), and stealth SaaS adop-

tion (Zainuddin, 2012). Only few studies focus on the individual perspective of personal devices use in the work context (Haag & Eckhardt, 2014).

This study explores the individual level Shadow IT use in the manufacturing domain. Competences of human workers play an increasingly important role in today's manufacturing environments as they are simultaneously able to complement modern technology and perform knowledge-intensive work tasks more effectively compared to pure technical approaches. However, this also calls for improved knowledge management. The increased digitization and automation of the manufacturing environment (Schmidt et al., 2015) has not been matched by the digitization of the shop floor, i.e. the use of IT by workers to improve their knowledge work practices. The increasing pressure for efficiency on the one hand and the lack of IT support on the other, brings manufacturing workers into a difficult situation. It is not surprising that many of them turn towards IT that they are familiar with in their private life and which is easily usable in a work context (Baskerville, 2011). To understand in more detail what drives them to do this, we ask: *What drives knowledge workers to use private smartphones (and related applications) without formal company approval for work practices?*

Moreover, to the best of our knowledge there are currently no studies investigating in more detail the bottom-up appropriation of personal devices (Shadow IT) and its impact on manufacturing knowledge work practices. Therefore, we also ask: *How do knowledge workers use private smartphones (and related applications) in knowledge-intensive manufacturing practices?*

We present a case study of mobile maintenance practices in a manufacturing organisation. Through a series of observations and interviews, we became aware that a number of workers utilise their private smartphone devices to facilitate their work in a more efficient and effective manner. We researched this phenomenon in more detail and were able to get insights into the difficult situation that the workers are in. They are not officially allowed to use their private devices and yet find significant productivity gains through using them. Our study contributes to knowledge management research by showing how private IT use makes inroads into corporate knowledge practices. It informs management about the obvious urgent needs of knowledge-workers in manufacturing processes. These knowledge workers are willing to risk their job to be able to work with a more helpful device. At the same time, we are able to give rich insights into the increase of Shadow IT in the manufacturing domain which takes place in a self-organised way without the intervention of management. This enables us to take a step towards a knowledge management strategy perspective on the phenomenon of Shadow IT.

The remainder of the paper proceeds as follows. In the next section, we review the literature on the phenomenon of Shadow IT in organisations as well as a discussion of knowledge intensive work practices in the manufacturing sector. We then present our in-depth case study of a manufacturing organisation which explores the emergence and appropriation of private IT use in a manufacturing organisation. Next, we analyse and interpret our findings in the results section and also discuss the implications for the rise of Shadow IT on knowledge work practices in the manufacturing sector. Finally, we conclude with the limitations and present the avenues for future research.

2 Research Background

2.1 Shadow IT

Shadow IT can be defined as any IT resources voluntarily used by employees inside of the organisational ecosystem which have not received any formal IT department approval and exist as a reaction to perceived situational constraints (Behrens & Sedera, 2004; Györy et al., 2012; Haag & Eckhardt, 2014; Silic & Back, 2014). Prior research has found that if the existing IT infrastructure is insufficient to enable the accomplishment of important jobs (Diefendorff & Mehta, 2007; Martinko et al., 2002) there is a higher likelihood that individuals will be motivated to reach for alternative IT resources and tools to help them (Haag & Eckhardt, 2014).

As a consequence, workers increasingly use their private devices for the primary objective of fulfilling their work tasks in a more effective and efficient manner (Haag, 2015; Haag & Eckhardt, 2014; Stadtmueller, 2013; Zimmermann & Rentrop, 2014). Traditionally, the increase of Shadow IT has been seen as providing a number of security risks to the IT department (and organisation). This includes intellectual property loss or theft (Strong & Volkoff, 2004), endangering organisational data flows and compliance issues (Jones et al., 2004). Shadow IT can also result in unofficial processes that are created in parallel to official processes (Zimmermann & Rentrop, 2014) which can be additionally problematic when current employees move on from the organisation. On the other hand, the use of these private devices for work purposes can also have numerous benefits for the organisation. Recent studies (Thomson, 2012; West, 2012) point to the benefits of mobile technologies in workplaces including increased employee responsiveness and decision-making speed, resolving internal issues faster and increasing employee productivity. In addition, the use of private IT for business purposes can be seen by employees to be more powerful and useful as well as easier and more fun to use than traditional business IT (Harris et al., 2012).

In this study, we choose to focus on private smartphone use. Mobile technologies, such as smartphones are no longer just devices that facilitate and support written and spoken communication, they have become mini-computers and constant companions in our daily life. Smartphones combine and integrate multiple media in one device such as audio, text and video. For example, users often use their smartphones to access the Internet, get directions, recommendations, or other location-based information, send or receive text messages or participate in a video call or video chat (PewResearchCenter, 2014). These functionalities can also be used in a manufacturing setting in order to: 1) share details about a current issue via photos or videos, 2) to validate the workers' opinion about the further procedure or 3) to collaboratively find a solution (Waizenegger et al., 2016).

2.2 Knowledge-intensive manufacturing practices

Manufacturing companies today are encountering a rising number of product variants along with personnel ageing due to the demographic change (Herrmann et al., 2014). These challenges necessitate companies to develop their employees' competencies and to support related manufacturing knowledge practices (Patriotta, 2003; Virkkunen & Ahonen, 2004). In today's complex manufacturing environments currently the case that the knowledge requirements decrease with the level of automatization (MacCrory et al., 2014). Rather the topics of knowledge shift from a purely crafts knowledge with no automatization towards knowledge about the technical aspects of the machines in fully automated systems (David, 2015; Frey & Osborne, 2013). This corresponds to the shift in the worker's responsibility from producing goods towards keeping technical systems in a production environment within defined conditions of operation (Oliva & Kallenberg, 2003). Typical functions of employees working in this area include repair, inspection and maintenance activities that are performed on-site. These functions have the potential to significantly influence the performance of organisations (Aurich et al., 2006). However, these tasks vary in their objectives, required information and resources depending on their purpose (Aurich et al., 2010). Therefore, providing the workers with intelligent support and appropriate knowledge is crucial and a key driver for productivity (Bitner et al., 2010). Information needs emerge, often in an unexpected way during work on a machine on-site. These are not only about the task itself - like work order information - but also technical data about the products and procedure information. The increasing complexity of manufacturing environments demands better support by appropriate information systems being available where and when they are needed (Campatelli et al., 2016; Daeuble et al., 2015). However, little research on information needs and knowledge practices in the manufacturing sector has been conducted yet (Becker et al., 2011).

Along these lines and as stated above, we currently see increased usage of IT resources to support these knowledge practices without the knowledge of the management team. Research has shown that the increase of Shadow IT can create value for the organisation and that the employees can experience an increase in productivity and flexibility in their business processes. Furthermore, Shadow IT is much

broader for processes that are highly specific and involve a lot of uncertainty (Zimmermann et al., 2017). The aim of our paper is twofold, the first is to understand this phenomenon from a theoretical and practical angle to better support the employees. And the second is to raise awareness of the opportunities and challenges that arise from the use of private IT devices in a manufacturing work environment.

3 Study Design

The study talked about in this paper is part of an international research project. The purpose of the research project is to develop and demonstrate workplace solutions that support the inclusion of increasing elements of knowledge work on the factory floor. We examined the implications of the digitization on manufacturing companies in general and IT usage patterns from shop floor workers in details.

During the data collection process, some members of the research team observed the phenomenon of people making use of their private mobile phones to improve or facilitate their work, particularly where they worked in distributed teams. The explorative nature of the data collection enabled us to follow an "intuitive path" (Yin, 2015) and focus on the phenomenon of Shadow IT. Hence, we delved into the single case in order to get deeper insights into Shadow IT as observed in this particular group (Flyvbjerg, 2006) and to be able to study these complex situations in their specific context (Gibbert et al., 2008). Case study research is especially suitable for examining fields without comprehensive empirical material (Benbasat et al., 1987), as is the case with Shadow IT use in knowledge intensive manufacturing environments. We kept to the research approach that Eisenhardt (1989) proposed for data collection and case study analysis. Subjectivity plays an important role in the cognitive process of our research. So, instead of objectivity we provide inter-subjectivity (Dubé & Paré, 2003) by involving a team of researchers in the data collection and analysis phases. Through the team-based research as well as the elucidation of the data collection and analysis processes, we want to provide reproducibility and thus meet reliability demands. Therefore, we aim to provide maximal transparency, e.g. by revealing the single steps of analysis as well as by underpinning each argument with quotes from the case. The comparison of our findings with extant literature in the discussion section is aimed at ensuring validity. Finally, we establish a clear chain of evidence during the course of this paper in a way that allows readers to reconstruct our research journey from the initial research questions to the final conclusions (Yin, 2015). Whereas single case studies usually do not allow for statistical generalization, we refer to the "analytical generalization" (Gibbert et al., 2008) from our results to theory, rather than a population.

3.1 The case company

Our case study evolves around the fault repair and maintenance team of JAANU Corp., a worldwide operating producer of high-quality materials which employs several thousand people. We observed and interviewed a maintenance team that is responsible for the servicing and repairs of electrical and air-conditioning devices on a factory that spreads several square kilometres. For JAANU Corp., the specialist workers' knowledge in production is a crucial factor for fulfilling the constantly increasing requirements in quality and efficiency, which also result in increasing complexity of work. The dwindling number of employees and shorter training periods demand ongoing professional support and development of employees' knowledge and competencies. In our context "knowledge" means an individual's familiarity, awareness, or understanding of a subject such as a particular machine whereas "competencies" describe a combination of work-related knowledge, abilities, and skills (Nordhaug, 1993).

While troubleshooting, the employees face a number of challenges: Initially, faults are reported via telephone, e-mail or fax. Subsequently, this coarse-grained information on the type of fault and system is handed to the mobile maintenance staff in the form of a paper document. Frequently, neither the direct route to the fault's location is known, nor is a map available on the fault's surroundings. De-

pending on the location of the faulty part, personal protective equipment might be necessary and/or special entry and exit procedures have to be executed. We learned from the interviews, that new employees need an average of two years' experience before (1) they know their way around in this environment, (2) they are familiar with the conditions in most of the factory buildings and (3) they can troubleshoot autonomously. The necessary knowledge has to be acquired through experience which happens through mutual assistance provided by experienced colleagues, or through systematic trial and error iterations over time.

With the large number of units to be serviced and possibly repaired, maintenance employees rarely have all the relevant information at hand to solve a specific problem. This results in a significant effort to gather more information. Similarly, when spare parts are needed the workshop has to be contacted, or personally visited, as information on the availability of these parts and the status of order transactions are unavailable to the maintenance personnel when they are mobile.

Due to this great amount of implicit knowledge about the location of the specific sites, the conditions of certain factory buildings, the troubleshooting procedures, the specification of certain machines and tools a sophisticated knowledge management strategy would be necessary. However, instead of an explicit knowledge management strategy, JANUU Corp. follows an ad-hoc role modelling approach so that the younger employees are able learn about the work practices from the more experienced employees. Furthermore, in terms of data and knowledge storage they still rely on paper artefacts in terms of maps, machine guidelines and troubleshooting procedures. These rather "old-fashioned" knowledge management practices are perceived as cumbersome and time-consuming by the employees and are the pivotal trigger for the increase use of Shadow IT.

3.2 Data Collection and Analysis

The data collection at JAANU Corp. took place in two rounds between March 2015 and October 2016. We used different collection techniques and data sources (Benbasat et al., 1987) to achieve richness and flexibility in the research process (Dubé & Paré, 2003). During the first round of data collection a very broad approach was adopted in order to understand how mobile maintenance workers complete their daily work, interact with each other and what tools are provided to support them. A team of 3 researchers observed employees from the repair and maintenance team during their work on the company site and held nine semi-structured interviews with an average length of 67 minutes. Furthermore, diverse internal documents such as handbooks, work lists, and process descriptions were also studied.

Whereas the first round of data collection was held in a relatively open way, the second round of data collection was rather focused. Four interviews with an average length of 27 minutes were conducted which enabled us to further deepen the understanding about using private devices for work purposes. These two rounds of data collection yielded to a satisfying depth as well as breadth of information (O'Reilly & Parker, 2012). The arising categories from the analysis of these interviews seemed to be robust (Charmaz, 2014) and we therefore agreed on having achieved adequate saturation (Bowen, 2008). The interviewees' age ranged from 29 years to 55 years. During the interviews, we adopted the role of neutral observers (Walsham, 2006), although we know this does not mean that we were unbiased, but we endeavoured to obtain answers from different perspectives that were as frank as possible. During the interviews, we asked questions spanning the following areas:

- General issues (age, existence of smartphone)
- Experience with smart devices in private lives and at work
- Opinion about private devices at work

The interviews were transcribed and encoded by one of the research team members. For the text documents, the qualitative content analysis method (Mayring, 2000) was employed. Firstly, we adopted an open coding approach (Glaser, 1992) to search for patterns based on the research questions about a)

what drives people to use Shadow IT and b) how people use Shadow IT guided this process. The identified patterns were revised in multiple loops of refinement by consulting existent theories and discussion within the research group until a common agreement on categories was achieved (Dubé & Paré, 2003). The final coding set contained five main categories that are reflected in the structure of the results. These categories are split between explaining the reasons for the use of private smartphones (poor work equipment, constraining work conditions) and exploring the knowledge-related work practices that are conducted with the support of private smartphones (knowledge discovery, knowledge storage, knowledge exchange). These categories lead us to recognize well-known patterns. For instance, Alavi and Leidner (2001) developed a framework, consisting of four sets of knowledge processes which represent an interconnected and intertwined set of activities. These processes are: (1) creation, (2) storage, (3) transfer, and (4) application. Whereas the first three processes are well covered by the categories as developed in our case study, we have not found any evidence for the fourth one (application).

4 Results

In the following results section, we will illustrate why the phenomenon of Shadow IT has unfolded in our case under study (4.1) and how the use of private smartphones has facilitated knowledge discovery, knowledge storage and knowledge exchange (4.2).

4.1 Why: Reasons for Shadow IT on the shop floor

JAANU Corp. provides each mobile maintenance and repair team, which usually consists of two employees, with one cell phone per shift to communicate with their colleagues. These phones are very basic without Internet access or applications. Although private mobile phones are forbidden and all workers are aware the main reasons for it (safety and data security), the vast majority of the observed and interviewed workers used their private devices on site.

In our interviews, we found evidence, that employees utilize their private smart phones at work for mainly two reasons (see also table 1): First, they feel inadequately equipped with modern IT that has the potential to facilitate their work by their employer (poor work equipment). Second, the "official" work procedures of how to solve a task are often very complicated and time-consuming (constraining work conditions). Mobile smart phones provide the opportunity to circumvent this.

Poor work equipment	Constraining work conditions
• Old mobile devices without functionalities for taking and sharing pictures, group messaging, or Internet access • Not enough work phones • No personal devices	• Large distances on-site • Different working times • Time pressure • Complicated processes (mostly paper based or personal)

Table 1. Reasons for using private smartphones

As the fault management process is strongly paper based, the rather rudimentary IT equipment often hampers the work practices and impedes knowledge access as well as sharing. For example, employees may engage in repair processes that other employees have already started. Specific knowledge is lacking because the employee with that knowledge, who has started the work, is not actually present. One employee mentions: "*It is quite difficult, to reach a particular person. We are ten people here in our team and have been provided with four cell phones. Hence, not everyone is reachable every time. [Only] when you pay attention in the morning to who is working with whom over the day, then you know, where to call.*" (I_12)

This hampers the maintenance process, which means individual employees have to invest unnecessary time, driving to certain areas multiple times which ultimately leads to frustration and stress. Sometimes it is even a challenge to reach a specific person as not everyone has a cell phone with them. So, they have to be very attentive in the morning and memorize who teams up with whom so that they know whom to call in the case they need to get some information or help.

However, it is not just the simple communication between the employees that is quite cumbersome, the poor IT equipment makes knowledge sharing extremely hazardous. If the workers face a problem on site, need information about a specific plant component, or have to document an incident, the easiest solution would be to take a picture and send it to their colleagues or superiors to get the information or help needed.

However, this is easier said than done, as one employee summarizes: *"As an example, I wanted to take a picture of a particular plant part and asked for the official way, how to do it: It is a very bureaucratic act. I would have to choose a camera, order it, pay 50 Euros for it, and in the end, I would have to wear another device around. I just don't feel like doing this work and carrying three devices. And it also takes too long."* (I_10)

To facilitate knowledge transfer the knowledge management team at JAANU Corp. have decided to build teams with older and younger employees. However, if they cannot help each other and need specific information such as the number of a facility or the details about a component they either call one of their other colleagues or they have to look up the information in paper files which they carry along with them or which are kept in a storage. These processes are very inefficient and slow, which affects the workers' productivity and work outcomes. Being faced with this situation on the one hand and embedded in the virtual world on the other hand, the employees bring their private smartphones to work in order to facilitate their work processes. Although, they are aware that they breach the company rules, they take this risk into account as the functionalities of their smartphones supports and facilitates their work practices to a great extent.

4.2 How: The role of Shadow IT in work practices

To explore the role of Shadow IT in the case company we categorize the observed work practices into knowledge discovery, knowledge storage, and knowledge exchange as deduced in the data analysis. In the following, we describe these changed practices and analyse the resulting effects.

4.2.1 Knowledge discovery

We found that the interviewees use internet search engines such as "Google" on their smartphone to look up information or to seek help on the Internet. Especially, in the case of old machines and facilities for which there are no longer instruction books available. Before they search painfully in any paper folders or try to reach their colleagues or superiors, they just look up the information on the Internet. One worker mentions: "*Now and then, I have an older appliance without any instruction manual. In that case, Google is my friend, quite simple. The only chance to do this [use Google] is with my private device.*" (I_04)

Some of the employees in our case study use manufacturing specific apps provided by for example Mitsubishi or SAP. These companies have discovered this market niche and provide information about facilities and machines, as well as tips and recommendations. These apps are another very important knowledge source beside the Internet or search engines in particular to get the required information and acquire the necessary knowledge, as one interviewee states: "*Yes, I use it at work. I look for plant data, or other information needed such as the meaning of particular failure LEDs. If you don't have this information on-site in a handbook, which is usually not the case, then you can search for it in the Internet. There are also apps for this purpose, e.g. the Mitsubishi troubleshooting app where exactly this information is provided*." (I_12)

Impact:
Since the uptake of smart devices at the work place employees do not have to search for hours in old excel files or paper folders kept in different storage places anymore. Being able to quicker solve problems and to complete work tasks timelier accelerated the actual knowledge discovery process to a great extent. Altogether the easy and convenient access to knowledge via search engines or particular apps leads to an increased efficiency and productivity.
Exemplary quote:
I_12: „*It is definitely an advantage to use my personal phone. It saves efforts and time. […] All documents are administered in a small inventory room in the basement. You get stuck when you have to look for any information there. If I have identification numbers, it is faster and easier to just look for in the Internet.*"

Table 2. Impact of Shadow IT on knowledge discovery

4.2.2 Knowledge storage

Beside knowledge discovery, knowledge storage is another challenge for the employees in our case study. They are conscious about the current loss of knowledge as older employees retire and take a lot of insider information and knowledge with them. As the employees are often overwhelmed by the vast amount of different facilities, components, security guidelines, and procedures they have to follow, some of them created themselves a kind of dictionary with text and photos on their private smartphones. They can access this information anytime and solve the problem in no time when they are on site. This leads to an increase in efficiency, time saving and better work outcomes. Furthermore, in case of an accident or an incident at the facility the employees often have to document what happened and how big the damage is for the company, the client and the insurance company. Due to the cumbersome process of taking handwritten notes and pictures with a camera, and eventually saving or printing them, some of the interviewees simplify this process by using their private smartphones. They take pictures and record other short information via WhatsApp to document the event for their superiors, colleagues and/or clients. Thus, not just in the case of accidents or incidents but also to create knowledge artefacts so that their colleagues or superiors can have a look at the information and know what to do or what happened. One worker states: "*A burned transformer that was not switched off, for example. Yes, it would swelter. And anyone would take a picture of this for documentation purposes. […] I would do this with my private phone.*" (I_09)

Impact:
The manufacturing workers feel often overwhelmed by all the guidelines and process steps they have to have in mind. The use of smartphones and the creation of an own knowledge base such as a dictionary with photos and descriptions as mentioned above, helps them to organised their information easier. The advantage to store company data on their private devices is so big, that they prefer to bear the risks of getting troubles with their superiors (because of doing something forbidden) as well as the risks of damage and the costs occurring for usage fees. Furthermore, it is an important task in the construction sector to document particular events such as accidents or incidents for the purpose of optimal traceability. By using their private smartphones, employees get this work done easier and faster.
Exemplary quote:
I_13: "*I have all plants of our facility on my phone, both, written and graphic with pictures from the motor and identification label. So, I'll always know, immediate and fast, what has to be done.*"

Table 3. Impact of Shadow IT on knowledge storage

4.2.3 Knowledge exchange

Interpersonal information and knowledge exchange is the work practice which has changed most due to the uptake and usage of private smartphones. As the employees are often scattered around and work at different sites they need to talk to each other to discuss current issues and seek advice. For instance, when spare parts are needed, the workshop has to be contacted, or personally visited, as information on the availability of these parts and the status of order transactions are unavailable to the maintenance personnel. Moreover, the workers do not just work on different sites but also on the same site at different points of time. For this reason, they need to be able to reach each other to discuss the current status of the work, e.g. possible issues and what needs still to be done. As mentioned by the interviewees, they often have to engage in repair processes that other employees have already started. In that case, specific knowledge is lacking when the employee with that knowledge is not available, or not present at the fault's location in order to transfer the case-specific knowledge. Consequently, when no direct contact is possible the maintenance process is hampered. Individual employees have to invest a considerable amount of time driving multiple times to certain areas. As not every employee has a mobile phone provided by the company they often use their private smartphones in these cases. For simple communication purposes, it does not really matter if they use smartphones or cell phones as they both provide the same functionality. However, some interviewees mentioned that they even set up call forwarding to their private phones to avoid wearing two or more devices with them. A worker states: "*When we go to a breakdown, and a colleague says that yesterday there was another one of us, and we know, he is not here right now, but just somewhere else, then we call this colleague from time to time [to inquire about the situation].*" (I_08)

Although calling each other is the most common way of communication, our participants also text or chat with each other using smartphone apps such as WhatsApp. Especially when the employees are at another site and need advice they use their private smartphones to exchange textual information and photos. Photos are often better than the verbal description as they also show the circumstances and what the facility or machine actually looks like. As the employees often work in dangerous environments and need quick and valuable advice, they just ask their colleagues or superiors for support, get the advice and can continue with their work. The colleagues and superiors literally get a better image of the situation faced. After sending a photo, they often also call their communication partner to discuss the issue faced or the information required as this is usually quicker than texting back and forth. Therefore, it is often a combination of WhatsApp use and conventional phone calls which helps the employees in their daily work processes: "*One of my colleagues was at the plant, took pictures and showed them to another one. They discussed what happened there. Being able to sending pictures was an advantage. We still explain much on the telephone which also works. But, with photos it is easier*." (I_07)

Impact:
The use of smartphones enables the manufacturing workers to bridge not only geographical but also temporal boundaries meaning that they do not just coordinate their work when they are working at different sites but also if they work in different shifts. It is crucial for their work outcome to exchange information about the work process and information about the facility in order to produce high quality outcome and avoid mistakes. The ability to exchange photos and videos allows them to provide a more holistic picture and get a better assessment of the situation faced while the „personal interactions" via phone help them to clarify misunderstandings and get answers in real time. This leads ultimately to a greater efficiency and a safer work environment which is of great importance especially on hazardous manufacturing sites. Furthermore, due to the easiness of taking photos and sending them around, knowledge exchange among the workers is much easier. Not having to go through the "official" cumbersome process anymore, leads to an increase in efficiency.

Exemplary quote:
I_10: "*The colleagues in our shift do a lot of communication via WhatsApp. E.g. take a picture from the crane, at a temperature of 70 degrees, and easily send it to the office where I sit. In that case, we can act prompt and quickly.*"

Table 4. Impact of Shadow IT on knowledge exchange

5 Discussion

Our study about the use of Shadow IT at JAANU Corp. shows how private IT use changes company knowledge practices and disrupts established knowledge management strategies. It illustrates the obvious needs of knowledge-workers in manufacturing processes: They are willing to risk their job just to be able to work with a more efficient and work-facilitating device. In this section, we will further theorise on the worker's perspective on Shadow IT based on insights from our empirical data. Next, we will take a step towards a knowledge management strategy perspective on Shadow IT.

5.1 The worker's perspective on Shadow IT

As illustrated above, the use of Shadow IT brings a lot of advantages from a JAANU worker's point of view. Employees have developed individual strategies to take advantage of their private smartphones for work purposes, in order to be able to get their work done better and faster. However, our study also showed that the workers' awareness of doing something forbidden leads to frustration with some of the employees. These feelings of frustration mainly arise from the perceived missing organisational support. Some interviewees feel "forced" to use their private smartphones to get their job done thoroughly and are frustrated about not being valued or supported with IS that is assumed to be self-evident. They are annoyed that management hampers their work processes and that they have to bear the costs as well as the risks of damage or loss during work.

Interestingly enough, the way that these manufacturing workers self-organise their appropriation and use of smartphones to facilitate their work practices creates new social norms within the context of their work. Social norms include statements of effective conduct and inform members of the group about what is typically done in a given situation (Cialdini & Trost, 1998; Haag & Eckhardt, 2014). Thus, while Shadow IT has traditionally been seen as predominantly negative, based on the illustrated workers' perspective, we demonstrate instead how the phenomenon of Shadow IT can help companies to come up with solutions to improve work practices.

5.2 Towards a knowledge management strategy perspective on Shadow IT

Organisations face a great challenge on how to appropriately cope with the increased use of private IT devices. On the one hand, they benefit from increasing productivity and motivation of their workers when they use their private smartphones. On the other hand, there are serious concerns about data security (Walters, 2013) and further issues like the blurring boundaries of private and business life (Köffer et al., 2015).

Our results can help to raise the awareness of companies to revisit their IT policies and give their employees the chance to participate when it comes to the introduction of new IT. With an increasing control of what Baskerville (2011) names individual information systems, people are able to better align preferred individual needs and organisational requirements. We suggest that organisations examine how shop floor workers are accomplishing their tasks in a more productive and efficient manner. Understanding the employees' motivation for using Shadow IT might be a first step towards a proactive knowledge management strategy (Matijacic et al., 2013). The prevalence of using mobile phone devices has led some organisations to adapt their communication strategies, once they come to appreciate the increases in operational efficiency and productivity (Bott et al., 2010). Having understood that, these IT-enabled process innovations (Davenport, 2013) are to be incorporated into their mainstream

IT policies. It is important to find solutions that are able to support emergent knowledge processes, as described in this case study, where knowledge is distributed and where it is hard to predict who will participate in the process (Markus et al., 2002). Thereby, IT should be seen as an enabler of business objectives and help achieve them in the most efficient way possible (Luftman & Kempaiah, 2007).

Haag and Eckhardt (2014) ask: "How can organisations counteract employees' motivation to use Shadow IT". We turn this question around by rather asking: "What can we learn from Shadow IT use to improve the existing IT infrastructure?" We suggest to explore how organisations can leverage their employee's use of private devices and explore the learning and innovation (Behrens, 2009) that can take place in organisations in terms of improved work practices. We concur with Niehaves et al. (2012), who suggest that employee initiated use of IT devices can increase employee productivity, job satisfaction and even an opportunity to reduce IT costs. Moreover, Harris et al. (2012) suggest different strategies that can support organisations in facilitating the bottom-up appropriation of private devices for work practices – or in other words: how to cope with "the reverse technology adoption life cycle" (Andriole, 2012).

As a next step, a supportive environment that encourages the bottom-up approach could also improve job satisfaction and thus employee retention. A study by Frey et al. (2013) found that if employees exhibited improved job performance by using their mobile devices for work purposes, they tended to stay longer with their current employers (Jeong et al., 2016). As previous research has reported (Wang, 2010) and according to the results of our case study, in order to attract and retain the right employees, organisations will need to increase the types of devices and applications that they offer and take over the risks and costs for it. Especially the younger employees expect to be adequately equipped with modern IT from their employer in order to be able to communicate in a way familiar to them from their private lives. If this is not considered, as in the case of JAANU Corp., many will bring their own device even if it is not allowed. Tarcan et al. (2010) assert that organisations should create a supportive and positive environment for their employees to adopt new technologies such as work-related mobile devices that enable more efficient work practices. Subsequently in our case study we can see that if shop floor workers did not feel frustrated or blocked by their organisation in their private smartphone use, they may be able to collaborate and share their experiences more freely, thereby enabling the organisations productivity and efficiency in the long run (Lam et al., 2007).

Finally, organisations become more effective if they enable their employees to reuse already existing knowledge by providing the appropriate knowledge to those that need it when it is needed (Richter et al., 2012). Creating a culture by rewarding and encouraging employees for seeking, sharing and creating knowledge instead of hoarding it might be a possibility to face that challenge (Singh et al., 2006). In particular, it is important for manufacturing organisations to understand what motivates workers for knowledge sharing and learning and what prevents them from doing so (Cetto et al., 2016; Paroutis & Al Saleh, 2009). New innovative digital technologies along with all the associated new work practices and organisation of work would empower workers to openly share their contributions to a communally updated pool of knowledge. Full utilization of worker generated content and peer sharing about best practices, problem solving and ideas stimulates organisational learning and even worker-driven innovation (Hannola et al., 2016).

6 Conclusions

6.1 Summary

The goal of this study was to demonstrate how the use of private smartphones can provide better support for knowledge intensive manufacturing practices. Due to a malfunctioning company IT infrastructure employees felt compelled to use their own mobile devices and this has changed the way that knowledge is discovered, stored, and exchanged at JAANU Corp. Moreover, as shown in our case study, Shadow IT is also able to disrupt established knowledge management strategies. We have seen

that Shadow IT is able to change the official knowledge management strategy from a more human-oriented one promoted by the organisation to an unofficial "Bridging the gap" knowledge management approach by the employees.

We found that the employees use their private smartphones in order to avoid mistakes, facilitate the collaboration, and save time and effort and thereby come up with new organisational knowledge management practices that are not currently facilitated by management. As our data showed, this ultimately leads to more efficient and faultless work processes.

We have furthermore, discussed theoretical implications in the previous section, such as the relevance of appropriate strategies, the linkage between knowledge practices with Shadow IT and established theory, and possible relationships between equipping employees with up-to-date IT and motivation. We thereby, contribute to a better understanding of Shadow IT and its placement in different research streams.

We suggest that by bringing private smartphones "out of the shadow" may further improve knowledge processes. This can be achieved on the one hand, by establishing a company-wide standard, for example on technical data that is provided to all employees (also the ones that do not have or do not want to use a private device at work). And on the other hand, by being able to support diverse processes such as the knowledge application process (e.g., Alavi & Leidner, 2001), in more depth and breadth. Furthermore, although knowledge management practices themselves are important to companies for innovation and competitive purposes, providing appropriate organisational support further enhances these practices and leads to an additional increase in performance (Donate & Pablo, 2015).

6.2 Limitations

We neither claim that our results are representative nor that the saturation level we have reached with the data collection means completeness in terms of understanding (Nelson, 2016), the explorative character of this case study nevertheless produced robust categories and interesting results. Our approach allowed for drawing attention to the question of what specially can be learned about the single case rather than to generalize beyond it (Stake, 2005). We are aware, that the significance of our arguments is limited due to qualitative research's well-known restrictions. In order to assess the rigor of our research, we tried to meet quality demands such as multiple data collection methods, controlled deductions, and analytical generalizability (Gibbert et al., 2008).

6.3 Future works

Analysing the case study revealed further research needs. An interesting finding/potential for future direction is the hint of digital divide. Incidentally, we noticed, that the use of smartphones and diverse smartphone apps seem to be much easier for younger people who are more tech-savvy (Vodanovich et al., 2010) rather than their older colleagues (Wang et al., 2013). The abundance of information made available through technology is especially useful for Millennials who are very comfortable at rapidly obtaining and filtering material to acquire desired information (Hershatter & Epstein, 2010). This is a useful skill that should be leveraged by organisations.

Furthermore, based on the results gathered from this case study, we currently work on developing a workplace solution in terms of a mobile system that supports the inclusion of increasing elements of knowledge work on the factory floor. It is aimed to cover the whole knowledge process from discovering, via storage and exchange, up to application. In this context, further investigation of the knowledge application is needed, as we have not found evidence for that process in our data. We furthermore plan to expand the scope of our study to get deeper insights on the phenomenon of Shadow IT from other perspectives such as from different firms or industries. It is of particular interest, to explore how companies face the task of transferring the Shadow IT into secure organisational environments and how employees react to that and in turn adapt their work processes.

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